

## Discussion of TOPEX Side B Cal Mode Range Drift from Cycles 364 to 366

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### Introduction

In mid-August 2002 we described an apparent drift observed in the TOPEX altimeter's internal calibration mode's range measurement in the brief report "Discussion of TOPEX Side B Cal Mode Range Drift in Cycle 364", G. S. Hayne and D. W. Hancock III, August 15, 2002 ( available at <http://topex.wff.nasa.gov/docs/calldht.pdf>). We reported then that the calibration mode combined (Ku & C) delta range had made a relatively sudden downward step of about 5 mm in the first half of cycle 364 and then was continuing at the new apparently stable value. The combined delta range change was almost entirely due to a change in the Ku-band Cal-1 delta range.

With another three weeks of data in hand since August 15, we now see that the Cal-1 combined delta range has not stayed at the 5 mm low value but has returned almost to the vicinity of its values prior to cycle 364. The combined Cal-1 delta range changes continue to be due almost entirely to Ku-band Cal-1 delta range changes. We will describe the recent changes that have occurred since our August 15 report. The reader should see that earlier report for a description of the TOPEX altimeter's calibration mode and our use of the term Cal-1. Today's report is again restricted to data from Step 5 of Cal Mode 1.

### Cal-1 Delta Range Results

Figure 1 presents the TOPEX cycle averages of the Cal-1-derived delta ranges for the combined Ku- and C-band result. "Combined" refers to the weighted sum of Ku- and C-band results which eliminates path delays due to the ionospheric electron content, and "delta range" refers to the Cal-1 range after subtraction of an arbitrary but constant reference value. The last data cycle in Figure 1 is 366.

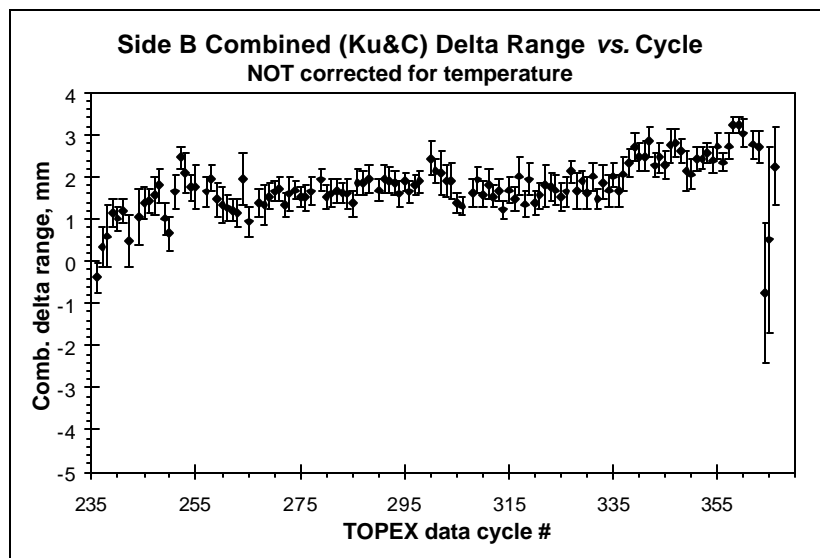
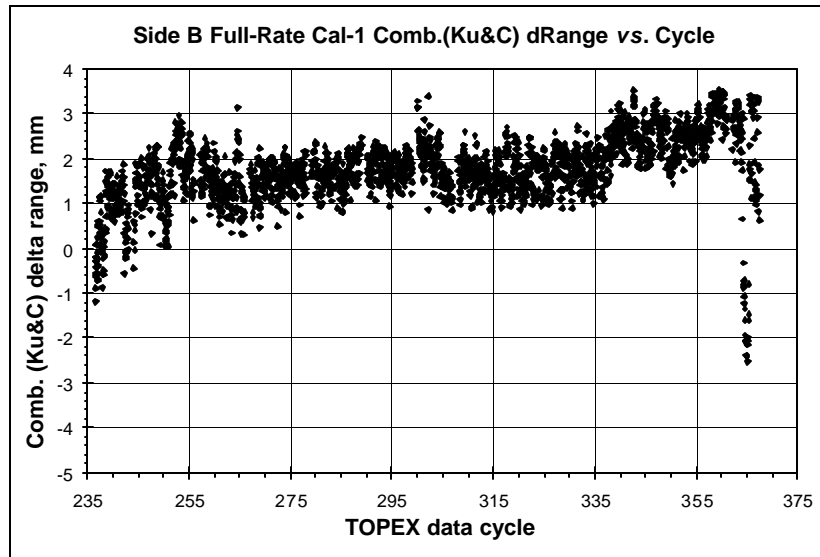


Figure 1

There are about 20 individual Cal-1 results in each of the cycle averages in Figure 1, and the error bars indicate the standard deviations in the averages.

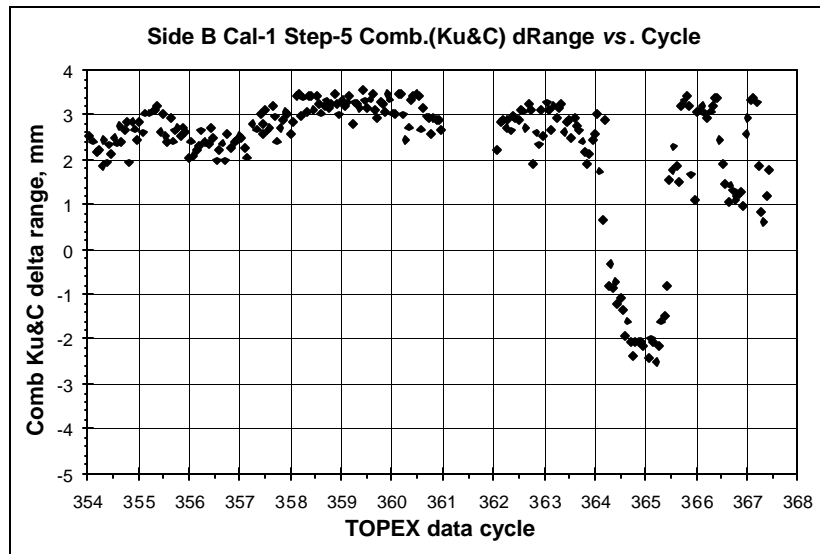
Figure 2 presents the full-rate Cal Mode combined delta ranges for Side B only. The last Cal Mode data plotted in Figure 2 was from 2002 day 247.



**Figure 2**

Our immediate concern is with the last two dozen or so Cal Mode delta ranges shown at the rightmost part of Figure 2. These Cal-1 combined delta ranges show a relatively sudden decrease of about 5 millimeters in the first half of cycle 364, followed by an apparent partial recovery. The next figure will show an expanded view of the right hand part of Figure 2.

Figure 3 shows the full-rate Cal Mode combined ranges from cycle 354 through part of cycle 367. Remember that there are two Cal Modes executed per day, for a total of 20 Cal Modes per data cycle. A rough characterization of Figure 3 is: 1) the Cal-1 combined range is approximately stable through the second Cal Mode of 2002 day 213; 2) this range decreases over the next six days; 3) for the following six days the range has a temporarily stable value (about 5 mm below the values from before cycle 364) starting with the second Cal Mode of 2002 day 219; 4) the combined range then tries to return to approximately its pre-cycle 364 value for several days; and 5) in the last two weeks the range still exhibits some uncertainty, bouncing around within 2 mm of its pre-cycle 364 value.



**Figure 3**

Our Figures have concentrated on the combined (Ku & C) Cal-1 range change, because it is the combined range that is of interest to the end user of the TOPEX data. This Cal-1 combined range change is almost entirely due to a change in the Cal-1 Ku-band range, and the Cal-1 C-band range has very little if any change over the time of the Ku-band change.

### Other investigations

We have seen no significant changes in the altimeter's point target response (PTR). The PTR is in effect the transmitted pulse shape as observed by the receiver, and through all of Side B operation the PTR has been monitored by execution of a special calibration sweep (Cal Sweep) mode approximately once per month. After the appearance of the Cal-1 range change in cycle 364, the frequency of the Cal Sweeps has been increased and a Cal Sweep is now executed once every 10-day data cycle. The latest Cal Sweep occurred on 2002 day 243, and we found no significant changes in that Cal Sweep's PTR compared to the PTR from any of the other recent Cal Sweeps.

A Cal Sweep starts as a regular Cal Mode, and the first four AGC steps proceed normally with about 10 seconds of data in each step. About 3-4 seconds into the fifth AGC step the altimeter's normal Cal Mode tracking is interrupted and the fine height is stepped through its entire range several times in a procedure lasting several minutes. From the first several seconds of Cal-1 Step 5 there is a normal Cal-range available. We have always deleted that Cal-1 range from our Cal-1 range data sets because all other Cal-1 ranges are based on about 10 seconds of data while the Cal-1 range from a Cal Sweep is based only on three seconds or so of data. Therefore Figures 1 - 3 do not include the Cal-1 Step 5 results from any Cal Sweeps.

As we said in our 15 August 2002 report, we have searched in all the temperatures, voltages, currents, and powers which are monitored in the TOPEX engineering mode data, and did not find any parameters strongly correlated with the Cal-1 range changes reported here. We have looked back at Cal-1 ranges in previous Cal Sweeps and found that on occasion the Step 5 (and Steps 1 - 4) ranges were approximately down about 5 mm. Also for the Cal Sweep on 2002 day 223, the Cal-1 range was up about 5 mm (near normal) during the period of time that the rest of the Cal-1 ranges were low.

During the period of the 5 mm low Cal-1 ranges in cycle 364, we did find a very minor change in the

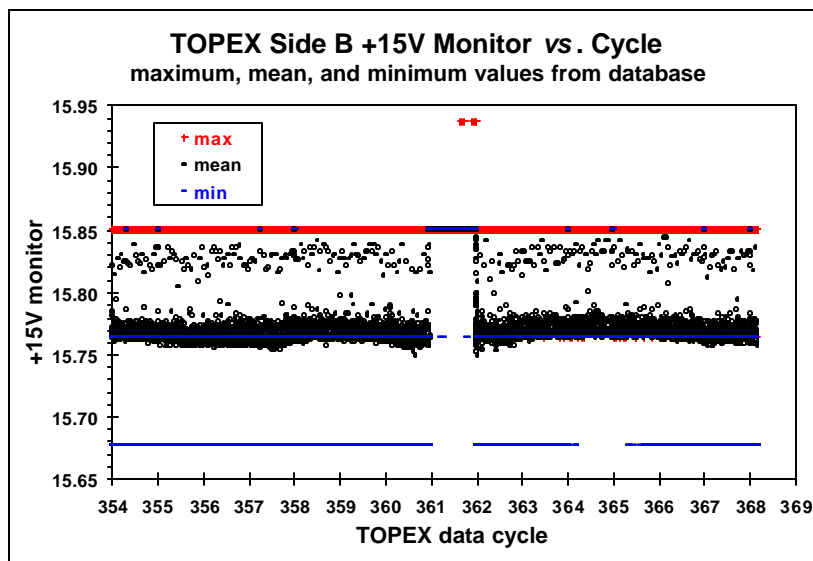


Figure 4

+15 volt readings. This small change is shown in Figure 4 which plots our engineering database's maximum, mean, and minimum values of the +15 volt monitor. Each database value represents 30 minutes of TOPEX engineering data (such as voltages) which are in the telemetry data about once every 8 seconds. The change at cycle 361 is expected because the CNES altimeter was on for that cycle. Look, however, at the plotted minimum values shortly after the start of cycle 364. These higher minima represent a single bit change from the values seen in the rest of the Side B history. This is the only time in Side B that we have seen this one-bit change in the +15 V monitor values in our database. We do not believe one-bit change is the cause of the range change but it might conceivably indicate something different in the altimeter's thermal environment. We know, from the altimeter's pre-launch thermal vacuum testing, that temperature changes could cause some changes in Cal Mode. Prior to a Cal Sweep the altimeter is placed in idle mode for a few minutes while a software patch is being loaded, and this can slightly change the thermal gradients within the altimeter. At this point we believe that thermal gradient changes might be one cause for our observations that 1) in the "normal" history of Side B prior to cycle 364, some Cal Sweeps (but not all) had low associated Cal-1 ranges while all other Cal-1 ranges were normal, and 2) during the anomalously low (by 5 mm) Cal-1 ranges in cycle 364, the Cal-1 range during a Cal Sweep was "normal". All the individual altimeter temperature values lie within ranges that have already been seen during the normal behavior of Side B. Since nothing abnormal is seen in the temperatures themselves, this leaves only thermal gradients (measured or unmeasured) as a possible explanation for the observed Cal-1 range changes in cycle 364.

## **Conclusion**

We note that the magnitude of the recent Cal-1 range change is only half a centimeter so it is the rate of the change, not the magnitude, which we find puzzling. These recent Cal-1 range changes are qualitatively unlike anything seen in the previous TOPEX Side B history. For now we can only wait and continue to monitor closely the altimeter data. In another month or so we expect to issue another update memo describing what has been seen in the additional three cycles of TOPEX data which will have been collected by then.